

Aug. 26, 1958

L. P. CLARK

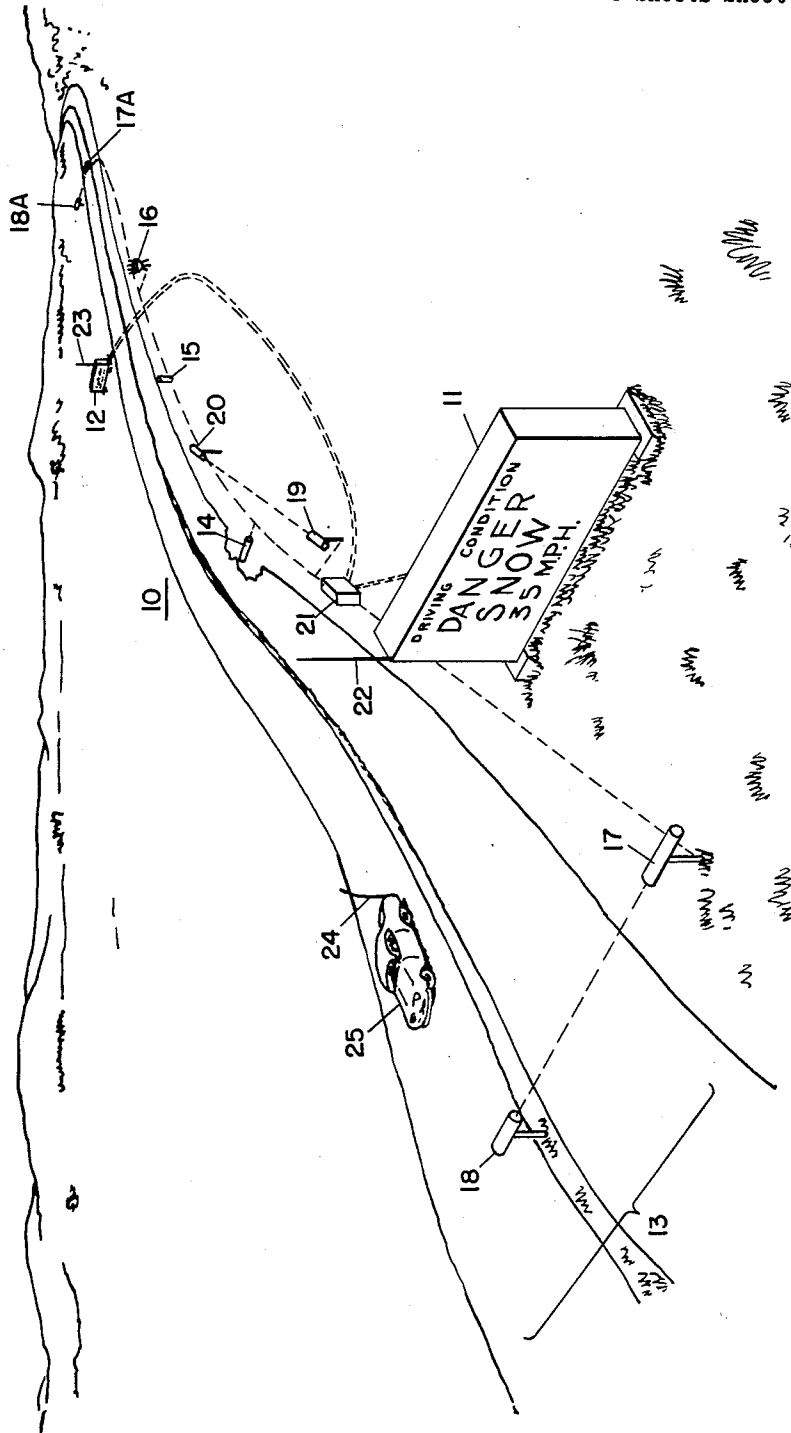
2,849,701

HIGHWAY CONDITION INDICATING SYSTEM

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5 Sheets-Sheet 1

Fig. 1



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HIGHWAY CONDITION INDICATING SYSTEM

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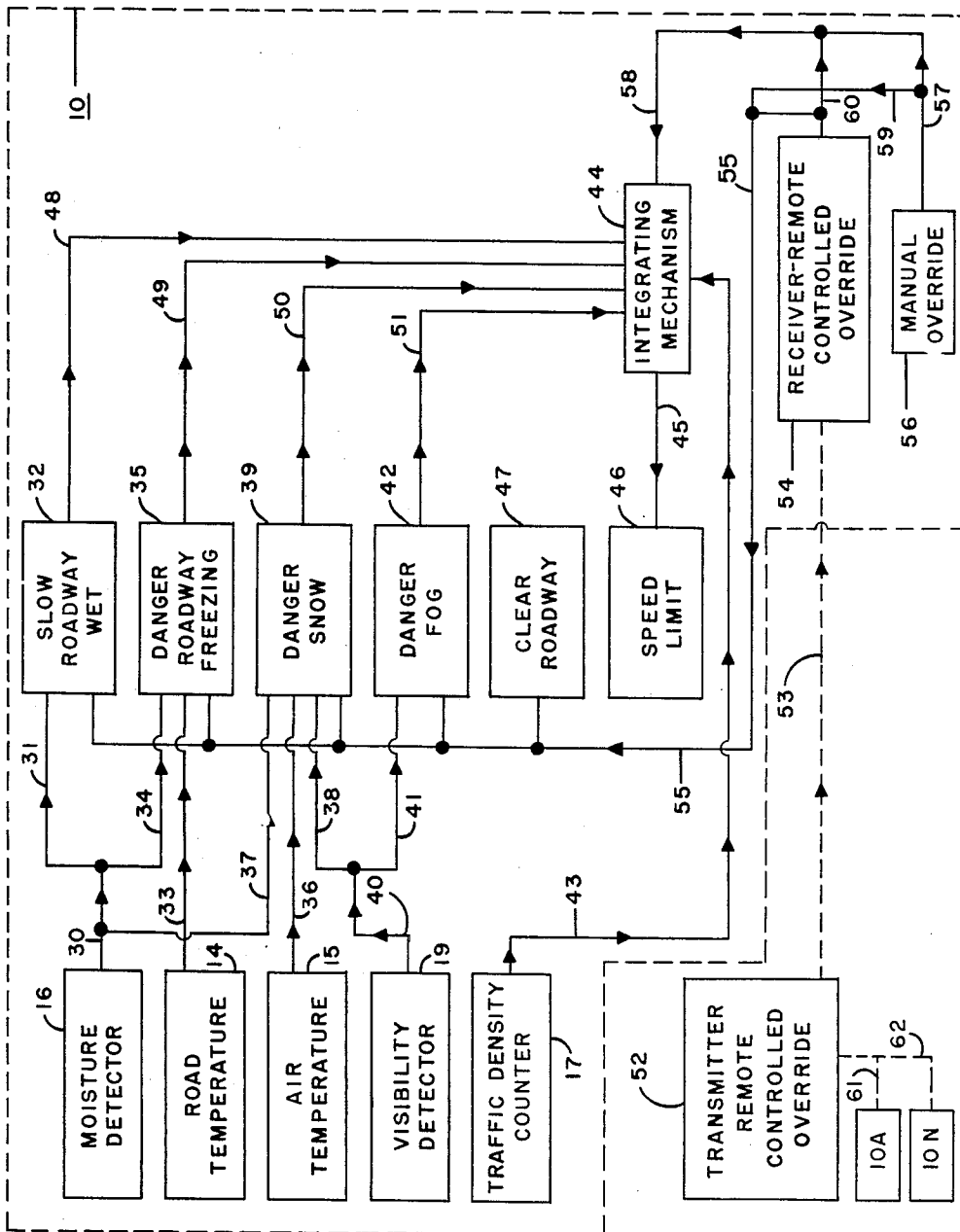


Fig. 2

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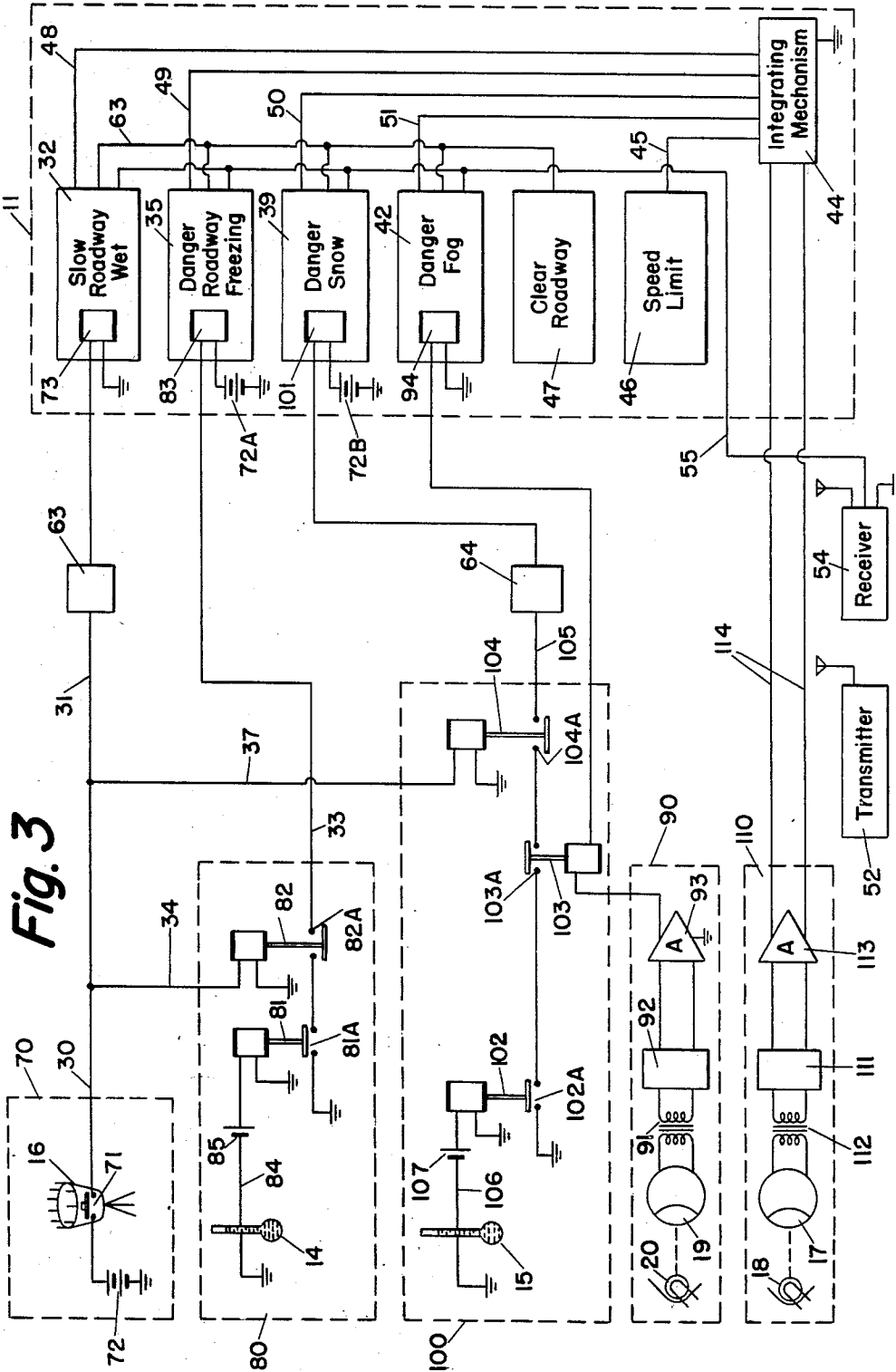
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HIGHWAY CONDITION INDICATING SYSTEM

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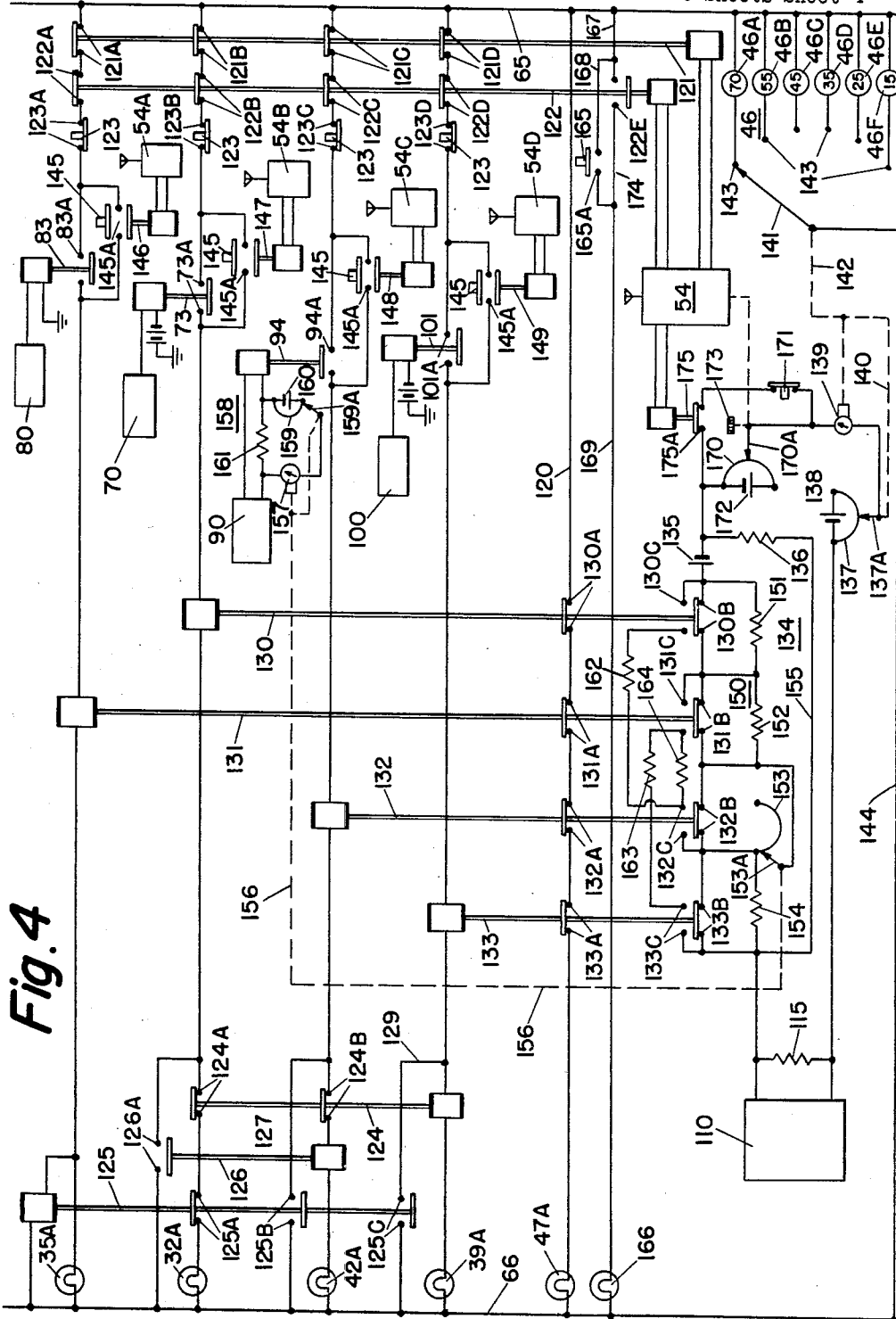
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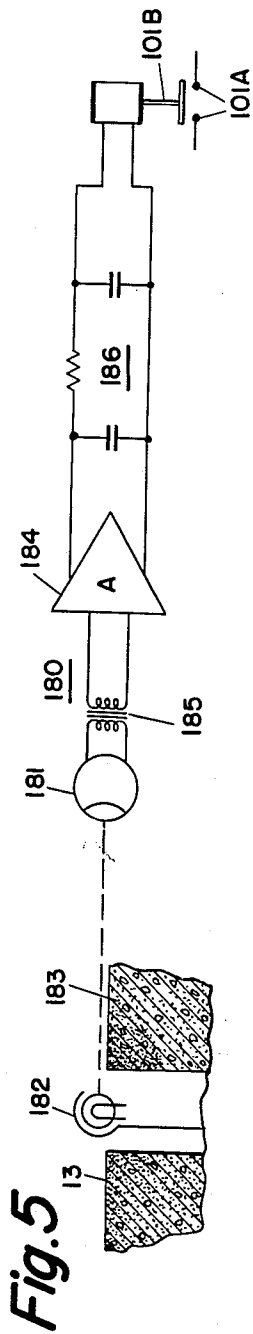
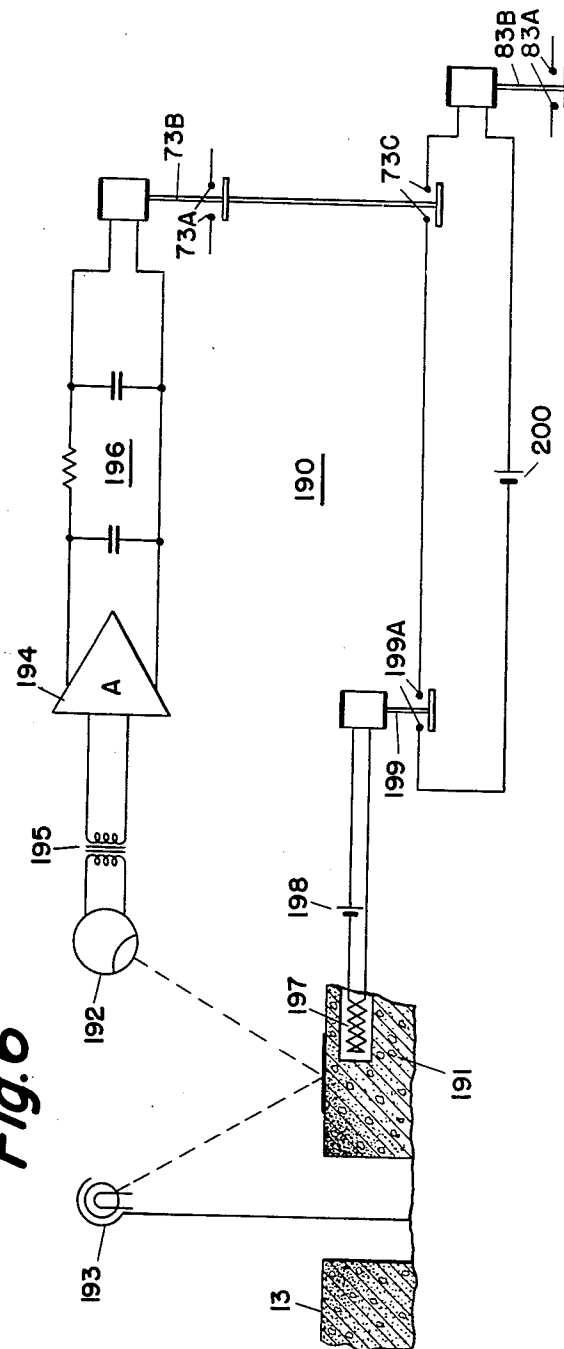


Fig. 6



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HIGHWAY CONDITION INDICATING SYSTEM

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Application April 23, 1954, Serial No. 425,131

18 Claims. (Cl. 340—22)

This invention relates to highway signs and signalling systems and has for an object the provision of suitable warning devices to inform a motorist of road conditions which he may face during his progress over a highway.

As superhighways have been developed, although there have been advance safety features engineered into their construction, there has been pointed out a long standing need of a highway condition indicator system that will apprise drivers of those hazardous conditions that arise suddenly when one travels long distances through various types of weather. Also it has been felt that the posting of such conditions along with a recommended speed limit will do much to reduce the accident rate that is caused by driver misinformation and misjudgment by giving the driver a true picture of what is ahead of him.

For example, it is not unusual to find a great change in the weather after passage through a long tunnel. The climate on one side of a mountain range frequently is quite different from that on another. In many cases speed limits have been arbitrarily reduced upon the occurrence of fog. In some cases electrical signs have indicated the reduced speed limit, these being set pursuant to the judgment of someone stationed on the superhighway.

There are many factors affecting safe driving which suggest reduction in the speed limit from the maximum permitted on a particular superhighway. Where optimum conditions permit a driving speed of seventy miles an hour or more, density of traffic alone may require speed reductions below the maximum for safe driving. Fog, ice, snow and rain may all contribute in a different degree to the needed reduction in the speed limit. Fog may be present together with rain. The surface temperature of the highway may be such that rain will freeze on striking the highway. Each and all of the variety of weather conditions when combined with the density of traffic dictate different speed limits for safe driving.

The present invention takes into account the many variables and provides maximum speed limits designed to minimize accidents due to all causes.

In carrying out the invention in one form there are provided along the highway a plurality of signs which may visually, and audibly if desired, indicate to the driver not only the safe speed but also the reason therefor. It is believed that by posting a recommended top limit at which the motorist should drive and also the reason, there will be achieved voluntary, in contrast with forced, observance. The signs are controlled by sensing devices which will detect the existence of such weather conditions as fog, ice, rain or snow and relay the information to the signs for indication to the motorists. Controls are provided for operation of the sign either locally or remotely therefrom, in either case overriding the control provided by the sensing devices.

For further objects and advantages of the invention, and for a more detailed understanding of the invention, reference is to be had to the following description taken in conjunction with the accompanying drawings wherein:

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Fig. 1 is a perspective view of a highway to which the invention has been applied;

Fig. 2 is a block diagram of a typical embodiment of the invention;

Fig. 3 is a more detailed wiring diagram diagrammatically illustrating the invention;

Fig. 4 is a wiring diagram showing in detail certain features of the invention; and,

Figs. 5 and 6 diagrammatically illustrate additional highway detectors.

Referring to the drawings, there appears in Fig. 1 a local station 10 of a condition-indicating system including signs 11 and 12, one for each direction travelled, located adjacent a divided highway 13. Associated with the highway are a number of condition-detecting or sensing devices. For example, a thermometer 14 embedded just below the surface of the highway 13 will provide an indication of the temperature thereof. The thermometer 14 may be of any suitable type including the resistance thermometer which may be preferred because it will not be subject to injury due to the vibration of the highway incident to the passage of trucks over it. A thermometer 15 of any suitable type exposed to the atmosphere, will provide an indication of air temperature.

A moisture detector 16 is positioned to one side of the highway 13 and responds to precipitation of any kind. The moisture detector 16 may respond differently to snow and to rain, suitable changes in its design being made to take care of the needs of a particular application of the invention. By means of a photoelectric cell or other light sensitive device 17 receiving light from a source 18, the density of traffic in one direction on a dual highway and entering the zone between signs 11 and 12 will be determined by the frequency of interruptions of the light beam. A similar arrangement consisting of light source 18A and photocell 17A may be installed at an opposite end of the zone to detect traffic density in the opposite direction.

The existence of fog, smoke or other visibility decreasing conditions may be detected by a circuit including a photocell or other light sensitive device 19 receiving light from a source 20 spaced therefrom along the side of the highway 13. The detecting devices 14—17, 17A and 19 may be respectively connected to a control box 21 and signals dispatched therefrom to the signs 11 and 12 to place upon them an indication of the particular driving condition, together with a general label "Danger" or a particular speed limit, or both. Alternatively, the components of control box 21 may be duplicated at each sign.

At the sign locations 11 and 12 there may be provided, respectively, antennae 22 and 23 with associated receiving equipment to receive overriding control signals from a transmitting antennae 24 which may be located at a central control station, at one of the booths of the highway, or as shown on a patrol car 25. Transmitting equipment may be provided at each of the foregoing locations any one of which can dispatch by radio, suitable coded signals to produce the change in the driving condition appearing on the respective signs 11, 12. It will frequently be desirable to have the overriding control available, such for example, as upon the occurrence of a wreck somewhat beyond the safe visibility of an approaching driver. Moreover, it will be advantageous to post driving conditions on the signs before their actual occurrence which would again suggest desirability of the overriding control which could cause the slow down of traffic somewhat before the arrival, for example, of a violent windstorm moving rapidly across the country.

In Fig. 2 the moisture detector 16 is shown in block diagram with its output signal applied directly by way of lines 30 and 31 to driving condition designations ap-

appearing in block 32, namely, "Slow, Roadway Wet." The road temperature detector or thermometer 14 applies to line 33 a signal, which if combined with a signal from moisture detector 16, as by way of line 34, will cause each sign to display the label appearing in block 35, namely, "Danger, Roadway Freezing." The air temperature detector or thermometer 15, applies a signal by way of line 36, which if combined with a signal from the moisture detector 16 by way of line 37 and another signal from the visibility detector 19 by way of line 38, produces on each road sign the label appearing in block 39, namely, "Danger, Snow." A signal from the visibility detector 19 by way of lines 40, 41 directly produces on the road signs 11 and 12, the label appearing in block 42, namely, "Danger, Fog."

The output from the photocell detector 17 serves as a traffic density detector. The output signal is applied by way of line 43 to an integrating mechanism 44, which in turn produces a signal by way of line 45 to a speed limit indicator shown in the block 46 which may concurrently appear on the road sign 11 in conjunction with any one of the preceding labels, including one appearing in block 47 indicating "Clear Roadway."

The signal from the traffic detector 17A, Fig. 1, will be applied to a separate integrating mechanism in conjunction with road sign 12. The mechanisms of sign 12 since identical to those of sign 11 need not be illustrated.

It will, of course, be understood that the various condition indicators here illustrated are exemplary of but one system arrangement and that other condition indicators and their associated detectors may be added without departing from the scope of the invention. For example, it may be desirable, in view of the present developments in the atomic energy field, to provide a means for detecting and indicating a dangerous concentration of radioactivity. The detector may be the well known Geiger counter whose output could be connected so to energize an appropriate indicator on the highway sign. In addition the motorist may be protected from poison gases, particularly those concentrated in a long tunnel, by provision of a suitable gas detector whose output would be applied to actuate a visual and/or audible indicating device. Although the particular arrangements have not been illustrated or specifically described, any one skilled in the art will be capable of connecting such detectors in the control circuitry hereinafter described.

The integrating mechanism 44 may be connected directly or indirectly to the various sensing devices. In the embodiment illustrated the integrating mechanism 44 responds to the various sensing devices in a manner now to be described.

The various condition indicators, exemplified by blocks 32, 35, 39 and 42 will, upon energization, produce signals which will be transmitted to the integrating mechanism 44. As illustrated, the integrating mechanism 44 is arranged to receive signals from the "Slow, Roadway Wet" indicator 32 by way of line 48; from the "Danger, Roadway Freezing" indicator 35 by way of line 49; from the "Danger, Snow" indicator 39 by way of line 50; and, from the "Danger, Fog" indicator 42 by way of line 51. The magnitudes of the several signals are taken into account in the mechanism 44 and the speed limit indicator 46 is varied in accordance with the sum of the signals.

Reference has already been made to the fact that an overriding signal would generally be desirable. In Fig. 2 a transmitter 52 may be arranged to send a control signal through a radio link as shown in Fig. 1. In Fig. 2 the signals from transmitter 52 are sent by way of a wire link 53, which might be more economically provided, to a receiver 54, the output of which is supplied by way of line 55, to the inputs of the highway condition indicators 32, 35, 39, 42 and 47. The signal may be applied to all the indicator inputs. However, through the use

of selective coding techniques, as for example, described in copending application of Roberts et al., Serial No. 189,581, filed October 11, 1950, and in a publication entitled "Hydrocorder" available from Raymond Rosen Engineering Products, Philadelphia 4, Pennsylvania, only the called indicator will respond. The speed limit indicator 46 may be changed directly upon transmission of an appropriate signal and application thereof by receiver 54 to the integrating mechanism 44 as by lines 60, 58.

A manually operated overriding device 56 located at each sign can be provided which through lines 57 and 58 will operate through the integrator 44 and the line 45 directly to change the speed limit displayed in block 46. The manual override 56 can also be applied to any one of the indicators or to any number of them as may be desired, the arrangement being diagrammatically indicated by the lines 59, 55.

Indicating stations 10 may be spaced along the entire length of a superhighway and arranged so that the control of each indicating station may be had from the transmitter 52, located at a central control point. Such a network for N-number of stations is diagrammatically illustrated by the blocks 10A and 10N representing the first and last of the local stations. Each station includes at least one but preferably two indicating signs 11, 12. The stations are respectively connected to the transmitter by radio or wire links diagrammatically illustrated by lines 61, 62.

Various types of detectors may be employed in the determination of highway driving conditions. In Fig. 3 one highway condition indicating station or system 10 is shown to include a series of suitable mechanisms for detecting such conditions as snow, ice, rain, fog and traffic density. The various detectors may be used in conjunction with a single road sign 11 or for a number of them. It is to be understood that these mechanisms are merely illustrative of detectors which may be used in the indicating system and that other devices, some of which are hereinafter described, may be employed in the practice of the invention.

The existence of rain and of a wet roadway or pavement may be ascertained by a moisture-responsive apparatus 70 of any suitable type such as the one now commercially available from the Motorola Company and identified as the "Thermel" device, model No. P8900. The apparatus 70 includes a moisture-responsive element 16 having a switch 71 responsive to precipitation of any type to energize the "Slow, Roadway Wet" indicator 32 by way of a circuit, from a suitable source of supply such as battery 72, which may be traced by way of the contacts of the switch 71, conductors 30 and 31, time-delay 63, and operating coil of a sign indicating control relay 73. A signal will also be sent to the integrating mechanism 44 by way of conductor 48 and a new speed limit on indicator 46 established. It may be an arbitrary safediving speed or it may be based upon the braking distance required to bring an automobile to standstill on the wet highway surface.

If during the period of precipitation as detected by the moisture detector 70, the highway surface temperature decreases below the freezing point, ice will be formed and this condition will be relayed to the highway indicating sign 11 by ice detector 80 and the "Danger, Roadway Freezing" indicator 35 will be energized. More particularly, the indicator 35 will be energized upon the operation of relays 81 and 82 and the resultant closure of a series circuit which may be traced from ground through relay contacts 81A, 82A, conductor 33, indicator control relay 83 and battery 72A. The contacts 81A are closed whenever the highway temperature drops to freezing or below.

Under normal conditions, a road temperature above freezing, the contacts 81A are opened by the energization of the relay 81 through a circuit including the conductive medium, mercury, of the thermometer 14, conductor 84,

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battery 85 and the operating coil of the relay 81. The thermometer 14 operates as a liquid switch in which the mercury moves into and out of engagement with spaced contacts (not shown) mounted in the path of mercury. A drop in road temperature to freezing and below will open the aforementioned circuit to deenergize the relay 81 and close contacts 81A.

Contacts 82A are controlled by relay 82 which is energized to close the contacts upon the occurrence of precipitation. The relay 82 is energized through a circuit which may be traced from the battery 72, the contacts of moisture detector switch 71, conductor 30, conductor 34, and the operating coil of the relay 82.

Upon the concurrent existence of precipitation and a road temperature below freezing, the contacts 81A and 82A will be closed to energize the "Danger, Roadway Freezing" indicator 35. A resultant signal will be transmitted to the integrating mechanism 44 by way of line 49 to effect a change in the speed limit indicator 46 in accordance with automobile braking distance under icing conditions.

The existence of fog or any other condition, such as smoke, which affects the degree of visibility along the highway is determined by visibility detector 90 comprised of the light source 20 and photocell 19 spaced a predetermined distance along the highway. The light source is preferably of the pulsating type in order to avoid interference in the system by stray sources of illumination. The output of the photocell 19 is accordingly coupled by way of transformer 91 to the input of a pulse counter 92. The pulse counter 92 may be of any well known type, for example, that illustrated on pages 251 et seq. of "Electronics": Experimental Techniques, by Elmore and Sands. The output of a pulse counter, as is well known, is a direct current (D. C.) voltage whose amplitude normally varies in a manner proportional to the frequency of the pulses applied to its input. In the application of the pulse counter to the proposed system the frequency is maintained constant. Advantage is taken of the fact that the D. C. voltage output also varies with a change in the amplitude of the pulses. Accordingly, as the visibility decreases, the intensity of light from the source will diminish to cause a reduction in the average voltage output of the pulse counter 92. To assure an adequate signal level for a clear atmosphere, a D. C. amplifier 93 of any well known type, is provided to raise the signal level sufficiently to maintain energized a fog indicating control relay 94.

The fog detecting system is arranged in such a manner that a decrease in the amplifier output below a predetermined value representative of optimum visibility or "Clear" conditions will cause the relay 94 to be deenergized and operate the "Danger, Fog" signal indicator 42. As will later be explained in detail the signal transmitted to the integrating mechanism 44 by way of line 51 changes the speed limit indicator 46 in accordance with the intensity of the fog.

The determination of the presence of snow may be made by a snow detector 100 whose operation is based upon the existence of poor visibility, low air temperature, and precipitation. The concurrent existence of the aforementioned conditions will energize a control relay 101 for the "Danger, Snow" indicator 39 by way of a circuit which may be traced from ground through relay contacts 102A, 103A, 104A, conductor 105, time-delay 64, the operating coil of relay 101, and battery 72B. Contacts 104A, which represent the existence of precipitation are closed by the energization of relay 104 by way of a circuit which may be traced from ground, battery 72, through closed contacts of switch 71 of the precipitation detector 70, conductor 30, conductor 37, and the operating coil of the relay 104. The contacts 103A representative of poor visibility are closed through the deenergization of relay 103 responsive to the decreased output of the fog detector amplifier 93. Contacts 102A representative of air tem-

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perature are controlled by the operation of relay 102 which is energized to hold the contacts open throughout a range of temperatures exceeding for example, 36° F., by way of a circuit which may be traced from ground through the conductive medium of thermometer switch 15, conductor 106, battery 107, and the operating coil of relay 102. Upon a reduction of air temperature below 36° thermometer switch 15 opens to deenergize the relay 102 and close contacts 102A. When the detector 100 operates to show the existence of falling snow, the indicator sign 39 is energized and a resultant signal is transmitted to the integrating mechanism 44 by way of line 50 to effect a change in the speed limit.

In the absence of any of the foregoing weather conditions, i. e., fog, rain, etc., the integrating mechanism returns the speed limit to the maximum allowable speed for optimum conditions. At the same time the "Clear Roadway" indicator is energized as by way of line 63.

It is well known that weather conditions may be short-lived and that rain and snow may fall for short periods. Since intermittent rain or snow may be considered to have a negligible effect upon driving conditions, means are provided to delay for a short time interval the energization of the rain and snow indicators 32 and 39. Accordingly, there may be provided in circuit with the rain detector 70, a time-delay mechanism 63, which will prevent the energization of the indicator 32 unless the precipitation as detected continues beyond a predetermined length of time. Such time may be manually set and may range from five to ten minutes. The time-delay mechanism 63 may be of any suitable type, a number of them being commercially available. A similar time-delay mechanism 64 may be included in the circuit of the snow detector 100.

Signals from the moisture detector 70, the ice detector 80 and the snow detector 100 can be taken as measures of the coefficient of road friction since each of the weather conditions detected affects the braking distance of an automobile. More particularly, rain in an amount producing a thoroughly wet highway (particularly if the highway is black top) greatly increases the distance required to bring an automobile to standstill because the coefficient of friction between the tire and road surface is materially reduced. Ice on a roadway so reduces the coefficient of friction that brakes may not with safety be continuously applied without danger of skidding. The occurrence of snow will reduce the coefficient of friction to a value between those produced by the occurrence of rain and ice. Thus the output signals from each of the foregoing detectors can be adjusted in magnitude to provide measure of coefficient of road friction with sufficient accuracy to predetermine the driving speed under each condition. As will be explained, should two unfavorable driving conditions occur, the signals resulting from operation of their respective indicators may be combined for reduction of the speed limit in accordance with the sum of the signals. If desired, other detecting means for directly measuring the coefficient of road friction may be employed in substitution for the illustrated condition detectors 70, 80 and 100.

As aforementioned, yet another factor governing highway driving conditions is traffic density which may be defined as the number of automobiles passing a point on the highway during a given time interval. With increasing traffic density there is a corresponding increase in accident rate which is due to the violation on the part of the motorist of the assured-safe-distance-ahead rule. The rule, as is well known, is based upon braking distance and reaction time. With the view of preventing the all too common chain reaction type collision, there is provided a traffic density detector to effect a reduction in speed limit whenever the motorists violate the foregoing rule. The detector mechanism changes the speed limit in accordance with the distance between automobiles to a speed appropriate for the distance separating the cars.

The traffic density detector 110 includes the steady light

source 18 and the photocell 17 so arranged that the beam of light from the source is interrupted by passing automobiles to produce pulses which will be representative of the number of automobiles passing the detector. The spacing between pulses also provides useful information. The detector 110 is located in advance of the sign 11 and in advance of the various weather and road condition detectors. The output of the photocell 17 is coupled to a pulse counter 111 by way of transformer 112. The pulse counter 111, which may be similar to the pulse counter 92, will produce a D. C. voltage whose average value is proportional to the frequency of pulses applied to its input. The D. C. voltage thus produced is amplified by a D. C. amplifier 113, the output of which is fed into the integrating mechanism 44, as by conductors 114, where a new appropriate speed limit is calculated and the speed limit indicator 46 changed accordingly.

Other sources of information may be fed into the sign indicator 11 so as to keep motorists fully informed as to driving conditions which may be encountered and, if desired, also to vary the speed limit on the highway in accordance with these conditions.

Referring now to Fig. 4, there is schematically illustrated a circuit responsive to the various condition detectors for effecting changes in sign indication and speed limit. In the absence of adverse driving conditions caused by weather, the "Clear Roadway" signal will appear due to the energization of an indicating device such as lamp 47A through a circuit which may be traced from right-hand supply line 65, conductor 120, relay contacts 130A—133A, lamp 47A, and to the other supply line 66.

The lamp 47A will remain energized to indicate to motorists that the roadway is clear until the occurrence of some adverse condition.

An icing condition will cause a signal from the detector 80 to energize the indicator control relay 83 to close contacts 83A. The closure of contacts 83A will energize an indicating device such as lamp 35A through a circuit which may be traced from supply line 65, contacts 121A, 122A, 123A, 83A, the operating coil of relay 131, lamp 35A and supply line 66. Similarly, the "Roadway Wet" indicator 32A will be energized by the operation of relay 73 in response to the moisture detector 70 to close contacts 73A and complete a circuit which may be traced from supply line 65, contacts 121B, 122B, 123B, 73A, the operating coil of relay 130, contacts 124A, 125A, lamp 32A and supply line 66. The fog indicator 42A is illuminated by the operation of relay 94 in response to a decreased signal from the fog detector 90 to close contacts 90A and thereby complete an energizing circuit for the lamp which may be traced from supply line 65, contacts 121C, 122C, 123C, 94A, the operating coil of relay 132, contacts 124B, the operating coil of relay 126, the lamp 42A and supply line 66. In a like manner, the snow indicator 39A is energized by the operation of relay 101 in response to a signal from the snow detector 100 to close relay contacts 101A and complete a circuit which may be traced from supply line 65 through contacts 121D, 122D, 123D, 101A, the operating coil of relay 133, the operating coil of relay 124, lamp 39A and the supply line 66.

The operation or energization of any of the indicating devices such as lamps 32A, 35A, 42A, 39A will result in the operation of an associated relay 130—133 to open the series circuit including the "Clear Roadway" indicating device or lamp 47A to deenergize the same as by the opening of any one of the relay contacts 130A—133A.

The relays serve the second function of introducing into a balanceable network 134, which comprises the integrating mechanism 44, a change in value of impedance network 150 which initially unbalances the network 134 and causes it to seek a new balance and effect a change in the speed limit. This operation will now be described. The addition into the balancing network of an impedance

in series circuit with battery 135 changes the current flowing from the battery through the impedance or resistor 136. The potential difference between the voltage across the resistor 136 and the selected portion of voltage developed across potentiometer slidewire 137, supplied by battery 138, is detected by a detector 139 which adjusts slidewire contact 137A, as by shaft 140 to reduce the difference to zero. Simultaneously with the adjustment of the potentiometer slidewire contact 137A a change in position of commutator contact 141 is made, as by shaft 142, selectively to energize the one of the speed limit indicator lamps 46A—46F associated with the existent highway condition.

The indicator lamps 46A—46F, representative of highway speeds over a range of from seventy miles per hour to fifteen miles per hour, are selectively energized through a circuit which may be traced from left-hand supply line 66, conductor 144, adjustable contact 141, one of fixed contacts 143, one of lamps 46A—46F and to the other supply line 65. On clear days, under optimum driving conditions the adjustable contact 141 will be positioned to energize lamp 46A to indicate to motorists a speed limit of seventy miles per hour.

Under optimum driving conditions, the resistance or impedance of network 150 is zero; the series resistors 151—154 comprising in part the impedance network being shorted out by the closure of relay contacts 130B—133B, respectively. A resultant maximum current from battery 135 flows through resistor 136 to effect through operation of the detector 139, and speed limit indicator 46, an indication of the aforesaid speed of seventy miles per hour. An increase in impedance of the network 150, as by addition of any of resistors 151—154 will cause the indicated highway speed limit to decrease.

A signal from ice detector 80 will cause the relay 131 to become energized simultaneously with energization of indicator 35A to open contacts 131B and close the back contacts 131C. The impedance or resistor 152 will be included in series with the battery 135 to reduce the current flowing through the impedance 136 by way of a circuit which may be traced from one side of battery 135, contacts 130B, impedance 152, contacts 132B, contacts 133B, conductor 155, impedance 136 and to the other side of battery 135. The balanceable network 134 will seek a new balance and cause adjustment of contact 141 to energize indicator lamp 46E to indicate a speed limit of twenty-five miles per hour.

In like manner the impedance 151, 153, 154 respectively representing speed limits commensurate with the highway driving conditions of rain, fog and snow may be included in series circuit with battery 135. The energization of the rain indicator circuit will cause the connection of impedance 151 in circuit with battery 135 through the operation of relay 130 and the resultant opening of contacts 130B. The circuit thus completed may be traced from one side of battery 135, impedance 151, contacts 131B—133B, conductor 155, impedance 136 and the other side of battery 135. The unbalance thus created in network 134 will cause the network to seek a new balance and change the position of adjustable contact 141 to energize lamp 46B to indicate a highway speed limit of fifty-five miles per hour. It is to be understood that the speed limits set forth herein are merely exemplary, and that speed limits will be selected to meet the requirements of particular highways.

Similarly, upon the existence of snow, the snow indicator will be operated and the relay 133 energized to open contacts 133B. Impedance 154 will be added in series circuit with battery 135 to effect a change in highway speed limit by way of a circuit which may be traced from one side of battery 135, contacts 130B—132B, impedance 154, conductor 155, impedance 136 and to the other side of battery 135. The adjustable contact 141 will be moved by the balancing operation of network 134 to

energize the lamp 46D and indicate a speed limit of thirty-five miles per hour.

Upon the occurrence of decreased visibility as by a condition of fog, relay 132 is energized and opens contacts 132B. The impedance 153 which is preferably variable, is adjusted through a shaft 156 by a balance detector 157 included in balanceable network 158. The adjustment of the variable impedance 153 is made in accordance with the intensity of the fog by balancing the output of potentiometer slidewire 159, supplied by battery 160, against the voltage drop across impedance 161 determined by the output current from the fog detector 90. The detector 157 adjusts the output of slidewire potentiometer 159 by change in position of its slidewire contact 159A and concurrently changes the value of impedance or rheostat 153 by adjustment of the movable contact 153A. The variable impedance or rheostat 153, included in series with battery 135 by way of a circuit which may be traced from one side of battery 135, contacts 130B, 131B, rheostat 153, contacts 133B, conductor 155, impedance 136 and to the other side of battery 135, is thus adjusted to vary the highway speed in manner commensurate with the intensity of the fog. Accordingly, the speed limit may vary over a range from seventy to fifteen miles per hour.

Provision is made to take into account the concurrent existence of two weather conditions, for example, fog and ice, which together necessitate the setting of a lower speed limit than required for the existence of either alone. In carrying out this concept each of the relays 130—133 is provided respectively with back contacts 130C—133C, and impedance network 150 is provided with resistors 162—164 to be included in circuit with battery 135 upon closure of the back contacts. Upon the concurrent existence of fog and ice, impedances 152 and 153 are connected in series circuit and the total impedance is reduced to a desired value by the addition in parallel therewith of impedance 164 as by closure of back contacts 131C and 132C. The effect is a reduction in speed limit to a value less than the effect brought about by the sole existence of either ice or fog. The speed limit indicator may register twenty-five miles per hour, or upon the existence of intense fog may register fifteen miles per hour by energization of lamps 46E, 46F respectively.

By the addition and removal of the various impedances the integrator 44, in the particular embodiment illustrated, is arranged to take into account the concurrent existence of fog and rain, fog and ice, and snow and ice. It is to be understood that other combinations may be included but have here been omitted in the interest of reducing the complexity of the drawings.

Having described in detail the concurrent existence of fog and ice and its effect upon the operation of the integrator 44 and speed limit indicator 46, it now will be apparent that upon a concurrent existence of fog and rain the impedance network 150 will attain a value determined by serially connected impedances 151, 153 which are connected in parallel with impedance 162 by the closure of back contacts 130C, 132C and that upon a concurrent existence of snow and ice the impedance network 150 will attain a value determined by serially connected impedances 152 and 154 which will be connected in parallel with the impedance 163 by the closure of back contacts 131C, 133C.

The integrator 44 is also arranged to respond to changes in traffic density. The output current of traffic density detector 110 flows through impedance or resistor 115 connected in series with the potentiometer 137 and the weather condition impedance network 150 and introduces a component of voltage unbalance into the balanceable network 134. The resultant rebalancing of the network 134 causes a further adjustment of commutator contact 141 and the selective energization of the illuminating devices 46A—46F which comprise the speed indicator 46.

It will now be seen that the integrator mechanism 44 computes speed limits based upon changes in coefficient of road friction caused by rain, snow and ice; changes in visibility caused by fog or smoke; and changes in traffic density. All factors which affect the Assured-Safe-Distance-Ahead Rule are properly weighed to determine safe speeds.

In order to assure the display of but one condition, whenever there is concurrent existence of at least two weather conditions a selective operation is provided. Priority of elimination is provided on the basis of determining which of various conditions is deemed most dangerous to motorists. For example, ice has been selected as the most treacherous of highway driving conditions and thereafter the conditions of snow, fog, and rain. Accordingly, the existence of an ice condition will result in the energization of relay 125 which will cause the shorting out of the snow indicator 39A by the closure of a shorting circuit including conductor 129 and contacts 125C; the shorting of the fog indicator 42A as by the closure of contacts 125B which completes a shorting circuit 127; and the opening of the rain indicating circuit by the opening of contacts 125A. The shorting of the snow and fog indicators 39A, 42A, will not prevent the integrator 44 from taking into account the concurrent existence of ice and fog, and ice and snow and making proper changes in highway speed limit. For example, the relay 132 which controls the addition of an unbalance component into the integrator system due to the presence of fog may be energized by way of the parallel circuit 127 instead of the circuit including contacts 124B, the operating coil of relay 126 and fog indicator 42A. The closed circuit 129 will similarly permit the operation of relay 133 to include in the integrator 44 an unbalance component representative of the existence of snow.

The existence of snow as described above is determined by signals from a plurality of sensing devices including the moisture detector 70 and fog detector 90. In order to prevent the operation of the rain and fog indicating circuits under conditions of snow, relay 124 is provided, which when energized simultaneously with the illumination of the indicator 39A causes contacts 124A and 124B respectively in the rain and fog control circuits to be opened.

The existence of fog will cause the energization of relay 126 simultaneously with the illumination of the fog indicator 42A and will result in the closure of contacts 126A which shorts out the rain indicator 32A yet permits the integrator 44 to take cognizance of the co-existence of both conditions and to make proper changes in speed limit.

The various traffic condition indicators and the speed limit indicator may be operated independently of the various sensing devices by a plurality of overriding devices which may be manually or remotely operated. The addition of overriding devices will permit a selective operation of the highway signs under conditions where there is a failure of the sensing devices or where there exists a condition that the sensing devices are not designed to detect.

Each of the control circuits is provided with a manually operated pushbutton 145 which may be depressed to close a circuit bypassing each of the control relay contacts 73A, 83A, 94A, 101A and energizing the particular indicating device across supply lines 65, 66. For example, if there exists a patch of ice which is remote from the sensing means 80 but between the highway signs 11 and 12, defining the highway area under detection, an authorized person may warn motorists of this condition by depressing the contact 145 in the ice control circuit and closing contacts 145A which bypasses open contacts 83A and energizes the ice indicator 35A and relay 131 through a circuit which may be traced from supply line 65, contacts 121A—123A, 145A, the operating coil of relay 131, indicator 35A and to the

other supply line 66. The motorist is thereby warned of the condition since the integrator 44 changes the safe speed limit to a low value. The pushbutton switches 145 in the other indicator control circuits are operated in like manner to energize their associated indicators.

Supplementing the manual switches there is provided a remote control arrangement including radio receivers 54A—54D which are associated respectively with the ice, rain, fog and snow indicators. A signal may be transmitted to a selected receiver as by a telemetric system of the type described in the aforementioned copending Roberts et al. application. Each of the receivers 54A—54D includes in its output circuit a relay which is responsive to a signal transmitted from a remote central station. These relays 146—149 respectively associated with receivers 54A—54D are operated to close contacts 45A in their respective control circuits and thereby perform through remote control the overriding function of the manually operated pushbutton 145. Although a plurality of receivers have been illustrated it will be understood that one frequency selective receiver may be employed.

A cut-off overriding arrangement has also been embodied in the present control circuits for selectively de-energizing the various indicator circuits. If one of the plurality of sensing means should produce a false signal, any one of the pushbuttons 123 may be operated to open its respective contacts 123A—123D and thereby open the affected control circuit to its supply line 65. The same cut-off overriding function may be performed from a remote central station by transmitting a signal to receiver 54 which includes in its output circuit a relay 121. By proper transmitted signal to the receiver 54 the relay 121 will become energized to open all control circuits to their supply line 65 as by the opening of contacts 121A—121D.

The safe highway speed indicator 46 may be locally or remotely controlled independently of the various detectors or sensing devices to provide means for warning the motorists of conditions which ordinarily can not be detected by automatic sensing devices. These conditions include traffic accidents where one or more lanes of the superhighway have been blocked, or detours, or defects in the roadbed, to name but a few.

For local operation there is provided a manual pushbutton 165 which upon depression closes its contacts 165A to complete a circuit to a "Danger" indicating device 166 through a circuit which may be traced from supply line 65, conductor 167, conductor 168, contacts 165A, conductor 169, the indicator 166 and to supply line 66. The speed limit may then be changed according to the nature of the danger to traffic by opening a circuit normally shorting a slidewire potentiometer 170 as by opening a switch 171. The slidewire potentiometer 170, supplied by battery 172, is then included in a series circuit with the detector 139 and slidewire 137. The speed limit may be changed by adjusting the position of slidewire contact 170A by a knob 173 to introduce into the balanceable network a component of unbalance commensurate with the desired speed limit.

If desired the other indications of highway conditions may be removed by opening contacts 123A—123D prior to the closure of contacts 165A to reduce the number of indications on the sign board, and thereby avoid possible confusion to the motorists.

The "Danger" overriding control which has been described above in conjunction with a local manually operated arrangement may also be performed from a remote central station by transmitting a proper signal to the receiver 54 and selectively energizing relay 122 which opens all highway condition indicator control circuits to their supply line 65 by the opening of contacts 122A—122D. Simultaneously, contacts 122E are closed to energize the "Danger" indicator 166 through a circuit which may be traced from supply line 65, conductor 167,

contacts 122E, conductors 174 and 169, the indicator 166 and supply line 66. Relay 175 in an output circuit of the receiver 54 may be selectively energized upon transmission of a proper signal to open the contacts 175A and include the slidewire potentiometer 170 in the balanceable network 134. The slidewire contact 170A may then be adjusted relative to the slidewire 170 as through a drive connection shown by the broken line extending to the receiver 54. Adjustment of the slidewire contact 170A will introduce an unbalance component of voltage into the balanceable network, the extent of which will vary the speed limit over the range from seventy miles per hour to fifteen miles per hour.

It is within the contemplation of the present invention that the remote control override may be modified to include a telemetering arrangement in which signals can be transmitted from the signs to the control station and there indicate to an operator the conditions detected and indicated by the individual signs.

Now that the principles of the invention have been explained, and one embodiment thereof fully described, it will be understood that many modifications may be made within the scope of the appended claims. While certain detectors have been described, others may be used, such for example, as those illustrated in Figs 5 and 6. These are to be taken as exemplary of still other types known to those skilled in the art.

In Fig. 5 a snow detector 180 comprises a photocell 181 arranged to receive illumination from a source of pulsating light 182. The light source 182 and the photocell 181 are illustrated as arranged at opposite ends of a platform 183 positioned adjacent the edge of highway 13. The light source and photocell are mounted above the upper surface thereof so that the beam of light will be interrupted by snow piling up on the surface of the platform. The light source 182 preferably should be of a type which produces a narrow beam of light so that it may be adjusted to a position very close to the surface of the platform.

The output of the photocell 181 is connected to the input of an amplifier 184 by way of a coupling transformer 185 and the signal output is increased to sufficient magnitude to hold relay 101B, which is in the snow indicator control circuit, in an energized position. A smooth output current for the operation of the relay 101B is obtained through the use of a filtering circuit 186 located in the output circuit of the amplifier 184. The piling of snow of sufficient height will cut off the beam of light from source 182 to cause the deenergization of relay 101B and the resultant closure of relay contacts 101A in the snow indicator control circuit. (Fig. 4.)

An advantage of the snow detector here described over the one illustrated in Fig. 3 resides in the fact that the detector 180 will sense the presence of snow on the highway and will continue to indicate a condition of snow as long as it is present, whereas in the first described detector 80 an indication of snow continues only so long as the conditions for actual fall of snow exist. In carrying out the principles of the snow detector 180, the platform 183 is comprised of roadbed material to have the same heat retentivity characteristics as the highway so that the melting of the snow on the platform will closely approximate the melting of snow on the highway.

In Fig. 6 there is illustrated a rain and ice detector arrangement 190 which applies the known principles that the reflectivity of the surface of a body will change when that surface is made wet. In the embodiment illustrated there is provided a block 191 formed of highway material or material having heat retentivity characteristics similar to those of the highway 13. The block 191, positioned adjacent the highway is provided with an upper surface which may be painted or otherwise coated with a black material such as a bituminous product. The reflectivity of the surface of the block 191 is measured by a detecting means including a photocell 192 and a pulsating

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source of light 193. The amount of light received by the photocell 192 will be a measure of the reflectivity of the blackened concrete block surface. Under ordinary conditions, in the absence of rain, the reflectivity of the block surface will be negligible. However, should rain fall, or the black surface of the block 191 otherwise become wet there will result an increase in light reflected into the photocell 192. The signal produced by the photocell 192 will then be placed in the input of an amplifier 194 by way of coupling transformer 195 where it is amplified to sufficient magnitude for operation of relay 73B and the closure of contacts 73A which are in the rain indicator control circuit. (Fig. 4.) The output circuit of the amplifier 194 may include a filter network 196 for smoothing the output current of the amplifier.

The relay 73B will remain energized until such time as the surface of the concrete block dries out, and since the block is possessed of the same characteristics as the highway, the drying off of the block surface will coincide with the drying off of the highway surface. It is to be noted that this embodiment of a highway surface moisture detector is responsive to indicate a wet highway surface independently of the source of moisture.

Operating in conjunction with the reflectivity detector to indicate the condition of icy roads, is a temperature measuring device such as a resistance thermometer 197 which lies embedded in the concrete block adjacent the upper surface thereof. A drop in road temperature and a corresponding drop in the temperature of the concrete block 191 will cause a reduction in the resistance of the thermometer 197 to effect an increase in current flowing from battery 198. When the temperature of the concrete block surface reaches the freezing temperature of water, the current flowing from the battery 198 will be sufficient to energize relay 199 to close contacts 199A. When simultaneously the reflectivity of the surface of block 191 increases, as with presence of moisture, relay 73B will be energized closing contacts 73C, and relay 83B will be energized from battery 200. Contacts 83A in the ice indicating circuit (Fig. 4) will be closed and cause a visual indication of the condition and a change in the speed limit.

What is claimed is:

1. A visual indicator system for continually apprising motorists of abnormal driving conditions comprising a signboard having mounted thereon a speed limit indicator, a plurality of weather condition-sensing devices for detecting the presence of rain, fog, ice and snow, a plurality of weather condition indicators associated with said weather condition-sensing devices and each mounted on said signboard, means responsive to signals from said weather condition-sensing devices for selectively energizing the associated condition indicators, means responsive to said sensing devices for adjusting the speed limit indicator in accordance with existing weather conditions, and means for assuring the energization of only one weather condition indicator at a given time.

2. A visual indicator system for warning motorists of abnormal driving conditions comprising a signboard, a plurality of weather condition-sensing devices for detecting the presence of rain, fog, ice and snow, a plurality of weather condition indicators and a speed limit indicator associated with said weather condition-sensing devices and each mounted on said signboard, means responsive to signals from said weather condition-sensing devices for selectively energizing the associated condition indicators, means responsive to said weather condition-sensing devices for varying said speed limit indicator, and means for assuring the energization of only one weather condition indicator at a given time.

3. A visual indicator system as in claim 2 in which a means is provided for delaying the operation of the means responsive to the snow detector for a predetermined period of time.

4. A visual indicator system for warning motorists of

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abnormal driving conditions comprising a signboard having mounted thereon a speed limit indicator and at least one driving condition indicator, sensing means for detecting the existence of an abnormal condition, means responsive to said sensing means for energizing said condition indicator, and means simultaneously responsive to said sensing means for adjusting said speed indicator to change the speed limit.

5. A visual indicator for warning motorists of abnormal driving conditions including visibility and road condition comprising a visual signaling device having a speed limit indicator and individual indicators for road condition and visibility, a road condition sensing means and a visibility sensing means having a location remote from the position of said visual signaling device, means associated with each indicator and responsive to said sensing means for selectively actuating said indicators upon change in driving conditions, and an integrating means responsive to said sensing means for varying the speed limit indicator in accordance with the changes in driving conditions.

6. A speed limit indicating system for informing motorists of a safe driving speed along a road comprising a visual signaling device having mounted thereon a speed limit indicator, a road condition indicator, means for detecting the coefficient of friction of the road, and means responsive to a change in the coefficient of road friction for changing the speed limit indicator and said road condition indicator in accordance therewith.

7. A visual indicating system for informing motorists of prevailing driving conditions at a point in advance of their position comprising a visual signaling device having visibility and speed limit indicators, sensing means for detecting changes in visibility along the roadway, means for detecting changes in the coefficient of road friction, means responsive to said visibility sensing means for actuating said visibility indicator, and means responsive to said sensing means and detecting means for varying the speed limit indicator in accordance with the magnitude of changes in visibility and changes in the coefficient of road friction.

8. The visual indicating system of claim 7 in which an overriding control means is provided for disabling the response of said visibility and speed indicators to said sensing means and to said detecting means, and for independently adjusting the speed limit through said speed varying means in accordance with conditions undetected by said sensing means and by said detecting means.

9. The visual indicating system of claim 7 in which there is included a traffic density detector whose output is applied to said speed varying means to effect changes in speed limit.

10. A visual indicating system for informing motorists of prevailing driving conditions at a point in advance of their position comprising a visual signaling device having driving condition and speed limit indicators, means for detecting changes in the road condition, means responsive to said detecting means for energizing said driving condition indicator to inform motorists of the nature of the road condition, and means for translating the change in road condition to a change in speed limit commensurate with the safe braking distance existing under the condition.

11. The combination with a highway signboard having display means for exhibiting one at a time a plurality of different speed limits to the motorist, a plurality of sensing devices respectively responsive to adverse weather conditions of a character which reduces the safe driving speed of an automobile in different degree from the maximum safe speed existing under optimum driving conditions, said signboard including means for exhibiting the maximum safe driving speed in the absence of signals from said sensing devices due to said adverse conditions, means responsive to each of said sensing devices for controlling

said display means for exhibiting a particular one of said safe driving speeds, and means responsive to signals from more than one of said sensing devices for reducing the safe driving speed exhibited by said signboard to a value below the maximum speed determined by one of the aforesaid sensing devices.

12. The combination of claim 11 in which weather condition indicating means are mounted on said signboard and responsive to signals from the sensing devices for posting on the signboard the weather condition causing the reduction in speed limit.

13. The combination of claim 12 in which means are provided for preventing more than one weather condition indicator being energized at a given time.

14. The combination set forth in claim 11 in which one of said sensing devices responds to change in range of vision due to the appearance of fog, smog, rain and smoke, and in which there is provided means operable under the control of said last-named sensing means for reducing said exhibited speed by degrees related to decreased range of vision.

15. A highway condition indicating system comprising a sign, a plurality of elements for displaying a weather condition on said sign, means for displaying a speed limit on said sign, a plurality of road condition sensing elements, a visibility sensing element, said road condition and visibility sensing elements having electrical output signals during operation, integrating means, means for applying said electrical signals from said road condition and visibility sensing elements to said integrating means to produce a single output signal, and means for applying said single output signal from said integrating means to said sign to simultaneously selectively control one of said plurality of elements displaying weather conditions and said means for displaying a speed limit whereby a predetermined relationship is provided between weather conditions and speed limit.

16. A visual indicating system for informing motorists of prevailing driving conditions at a point in advance of their position comprising a visual signaling device having visibility and speed limit indicators, sensing means for detecting changes in visibility along the roadway, means for detecting changes in the coefficient of road friction, means responsive to said visibility sensing means for actuating said visibility indicator, means responsive to said sensing means and detecting means for varying the speed limit indicator in accordance with the magnitude of changes in visibility and changes in the coefficient of road friction, and an overriding control means including a telemetering system for disabling the response of said visibility and speed indicators to said sensing means and to said detecting means, and for independently

adjusting the speed limit through said varying means in accordance with conditions undetected by said sensing means and by said detecting means.

17. A visual indicating system for informing motorists of prevailing driving conditions at a point in advance of their position comprising a visual signaling device having visibility and speed limit indicators, sensing means for detecting changes in visibility along the roadway, means for detecting changes in the coefficient of road friction, means responsive to said visibility sensing means for actuating said visibility indicator, means responsive to said sensing means and detecting means for varying the speed limit indicator in accordance with the magnitude of changes in visibility and changes in the coefficient of road friction, and an overriding control means located at said visual signaling device for disabling the response of said visibility and speed indicators to said sensing means and to said detecting means, and for independently adjusting the speed limit through said varying means in accordance with conditions undetected by said sensing means and by said detecting means.

18. A visual indicating system for informing motorists of prevailing driving conditions at a point in advance of their position comprising a visual signaling device having visibility and speed limit indicators, sensing means for detecting changes in visibility along the roadway, means for detecting changes in the coefficient of road friction, means responsive to said visibility sensing means for actuating said visibility indicator, means responsive to said sensing means and detecting means for varying the speed limit indicator in accordance with the magnitude of changes in visibility and changes in the coefficient of road friction, and an overriding control means located in a mobile unit for disabling the response of said visibility and speed indicators to said sensing means and to said detecting means, and for independently adjusting the speed limit through said varying means in accordance with conditions undetected by said sensing means and by said detecting means.

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